U.S. Army Test & Evaluation Command

Modeling & Simulation Office

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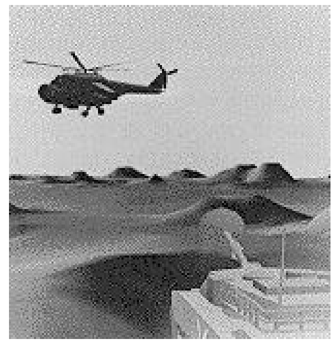
VIRTUAL PROVING GROUND



Acquisition Streamlining

NATO DRG '95 Seminar

ABSTRACT

The major thrust for the new Army acquisition strategy is modeling and simulation. Future acquisition will be more dependent on the use of engineering models and simulations for concept development and evaluation, long before hardware is built. To support the acquisition process in changing times, we need to leverage the technical power of modeling and simulation in the test and evaluation community. Clearly, modeling and simulation are playing an increasing role in augmenting the test and evaluation mission in an environment of decreasing financial resources. Application of modeling and simulation technology to developmental test and evaluation reduces time and cost of determining the true performance potential of new weapons technologies.

This paper presents the U.S. Army Test and Evaluation Command (TECOM) goals and process for developing a Virtual Proving Ground (VPG) to help streamline the future acquisition process. It discusses the traditional, current, and future test processes and technologies and examines how the right mix of live and virtual testing can save time and money with minimal risk.

The VPG is a computer-based synthetic test environment that enables testing of computer models, software, and hardware at the system, subsystem, and component level. It includes the databases, computer assets, software interfaces, and TECOM test expertise. It is the Army's tool to test computer models and simulations of systems so that design changes to these models can be implemented before "bending metal" when change is more costly. In addition, the VPG allows certain test issues to be addressed on a virtual range, thus minimizing and focusing the testing that has to be accomplished physically.

1. INTRODUCTION

The increasing power of cybernetic technology plays a vital role as the Army modernizes its power projection platform. One of our challenges is to find a faster process for delivering the most advanced and reliable capabilities to the warfighter, where and when needed. From basic research through testing to production, the current materiel acquisition process costs too much and takes too long to field a system. Sometimes Developmental Test and Evaluation (DT&E) alone can take several years to complete. This may not necessarily be caused by poor system design, but is often a result of premature hardware prototyping with inadequate prior testing. Future acquisition will devote considerable time and resources in the early design process. Future system designs will be focused by engineering models and simulations, long before hardware is built. The U.S. Army Test and Evaluation Command (TECOM) is re-engineering developmental testing through state-of-the-art modeling and simulation.

2. WHY DEVELOPMENTAL TEST AND EVALUATION (DT&E)?

DT&E is an integral part of the defense systems development and acquisition. It is a technical management tool that measures the system's progress on its journey from the design board to user's hands. When a new system is being developed, it is tested and evaluated against design specifications to ensure that it can do what it is supposed to do. DT&E identifies levels of performance to assist developer in improving system design. Per the DoDD 5000.1, DT&E occurs at each phase of the Life Cycle System Management Model to support decision makers at each milestone. DT&E is a significant tool for decision makers in managing the cost, schedule, and performance risks involved in developing a new weapon system. Test results are often used to support trade-off analysis, risk reduction, and refinement of requirements.

It is important to validate technology feasibility and engineering design before making a production decision and fielding a system. DT&E is the process of subjecting real objects or a system to a controlled environment, and measuring its performance. It addresses a system's technical parameters for both hardware and software. Test results are used to contribute to the decisions about acquiring and fielding an effective, supportable, and safe system.

3. TRADITIONAL DT&E PROCESS.

Traditional testing uses the actual hardware prototypes or production units. The hardware prototype is instrumented and subjected to measured, controlled, and repeatable test environments. The traditional methods involve destructive testing that can be cost-prohibitive. Very often, the conditions of the tests will destroy the system being tested. To get a sufficient sample size, many prototypes are used and many may be consumed or destroyed during tests. Examples of destructive testing are live-fire testing of tanks and helicopters, destructive "fly-before-you-buy" testing of munitions, and actual firing of missiles.

Developmental tests are normally conducted after the Concept Exploration and Definition Phase. Hardware prototypes are then built based on very limited laboratory testing and modeling and simulation. These hardware prototypes are tested during the demonstration and validation phase, and very often, the prototype being tested would face a “test-break-fix-test” mode. This traditional process does not allow adequate early testing to influence system design. It becomes time-consuming and costly to make any design changes after the DT&E. The total program also runs a high risk of cost increases and schedule delays.

4. CURRENT DT&E PROCESS.

Currently, TECOM uses extensive modeling and simulation to learn about the performance of systems tested. Modeling and simulation are not new in developmental testing. When working with hardware prototypes and production units in the acquisition process, TECOM uses extensive modeling and simulation to extend the knowledge of performance of systems under test, to extend the analysis of the systems' performance, and to compliment, and thereby reduce field testing. Current technology advances hold the promise that TECOM will be able to model actual test environment, stimuli, and procedures in sufficient detail and fidelity that they may be represented in interactive computer environments to support testing. Current capabilities include hardware-in-the-loop and human-in-the-loop simulations.

Hardware-in-the-loop simulation allows testing of the system without a fully built prototype. Subsystems or components of the system are built during the design phase. The remainder of the system is simulated and integrated with the actual hardware components for testing.

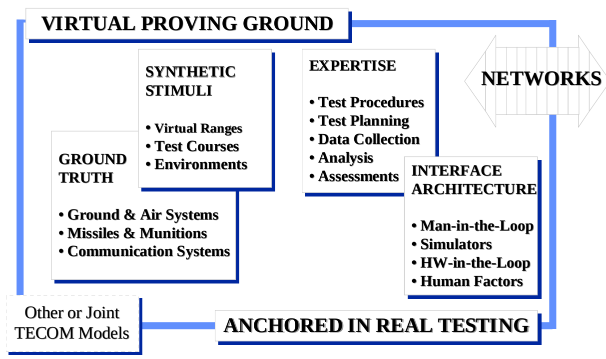
Human-in-the-loop simulation involves testing of equipment with operators in a laboratory environment. It provides early analysis of system performance, human factors engineering, and safety considerations of the system. It augments, and hence, reduces the time and cost of field testing. An example of such a test is the TOW missile system. Terrain with a moving target is simulated through the sight. The TOW operator tracks and fires at the simulated moving target as though operating the TOW in a field environment. The TOW system is instrumented and calibrated with the simulated images to measure the accuracy and the flight pattern of the missile in real time.

5. FUTURE TEST TECHNOLOGY.

The major thrust for the new Army acquisition strategy is modeling and simulation. Modeling and simulation is seeing increasing application as a tool to support all aspects of the acquisition process, and will play a critical role in acquisition streamlining. As the concept development and engineering design functions depend more heavily upon computer modeling and simulation, they create both a need and an opportunity to apply disciplined, valid developmental test and evaluation practices in the modeling and simulation environment.

TECOM is developing the Virtual Proving Ground (VPG) as a distributed interaction of computer-based models and simulations of our developmental test and evaluation facilities, environments, and procedures that will allow us to provide the same, and expanded, capabilities in the modeling and simulation domain, in support of the acquisition process. The VPG is a computer-based synthetic test environment that enables testing of computer models, software, and hardware at the system, subsystem, and component level. It includes the databases, computer assets, software interfaces, and TECOM test expertise. It is a technical keystone in the capability of the U.S. Army to maximize the effectiveness on future developmental testing.

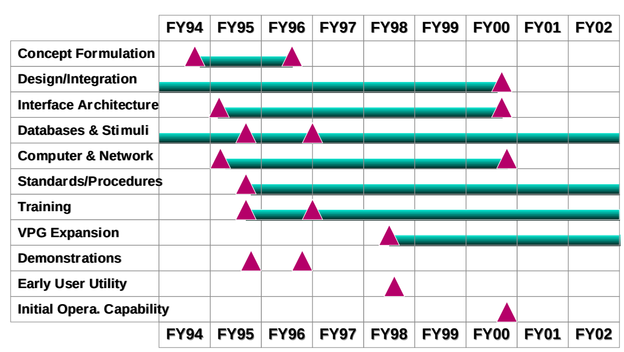
Concept



The concept of VPG includes interconnecting hardware and operators to immerse simulated or live test items into our distributed synthetic environments. TECOM has a unique mix of ranges, instrumentation, weapon systems expertise, and experience in hardware-in-the-loop simulation. This base will provide the ability to ensure that the test models and simulated test processes that are applied to future virtual prototypes will always be anchored in real hardware testing, and that the test results are traceable to live testing.

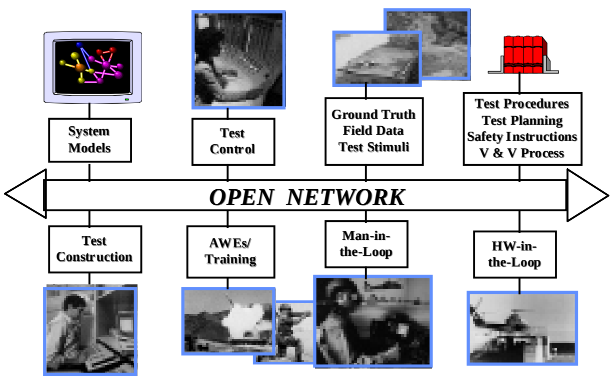
The synthetic, virtual environments and stimuli will be available to developers and users as the actual ranges and facilities are now. As a result, virtual testing will provide developers and users the ability to reduce risk early in the acquisition process before hardware exists. Additionally, certain test issues can be addressed on the virtual range, thus downsizing and focusing the testing that must be accomplished physically. In addition to the ability to influence design in a less costly way and to focus and minimize live testing, the virtual approach will allow extension of testing beyond normal limitations such as safety, environment, or geography.

VPG Milestone Schedule



The development of the VPG, brings together, and is built upon, many on-going efforts. Development is being initiated with coordination of existing TECOM modeling and simulation activities and verification that these activities are integrated with DoD modeling and simulation initiatives. Initial emphasis has been on concept definition and program administration. Studies of unique technical issues are being conducted and plans are being implemented to firmly establish the VPG in the suite of total technical test support to the acquisition community. As part of the VPG development, a pilot program has been started in FY95 to demonstrate the virtual test concept and compare the virtual test results to those of real testing.

VPG Architecture



In addition, a Technology Program Annex was established in November 1994 with the Army Research Laboratory to develop an open architecture. The architecture will provide the capability to support high fidelity simulation for instrumentation, testing, and ensure compatibility, interoperability, and interactivity of distributed simulation for test and evaluation through open architecture databases.

Extensive integration and coordination with the tri-service and Army major program offices have been initiated in FY95 and will continue in FY96 and the out-years as the VPG program matures. This effort will help us to identify early user utility and requirements for the VPG and ensure that there is leveraging of modeling and simulation technologies among the services. One goal is to provide early user utility to demonstrate the value of the VPG to streamline the acquisition of major Army programs.

Development of basic VPG virtual test capability will continue throughout FY96, with emphasis on further requirements definition, translation of ground truth data, and development of synthetic stimuli, synthetic test procedures, and test result presentation techniques. This focused effort will develop the basic elements for supporting early user utility of the VPG for several specific major Army acquisition programs. Instrumentation resources will be directed to support design and integration, studies of methods and instrumentation, and development of virtual test range capability and performance databases. Test Range and Facilities resources will support modernization of facilities and procedures for integration into the VPG and procurement of essential equipment.

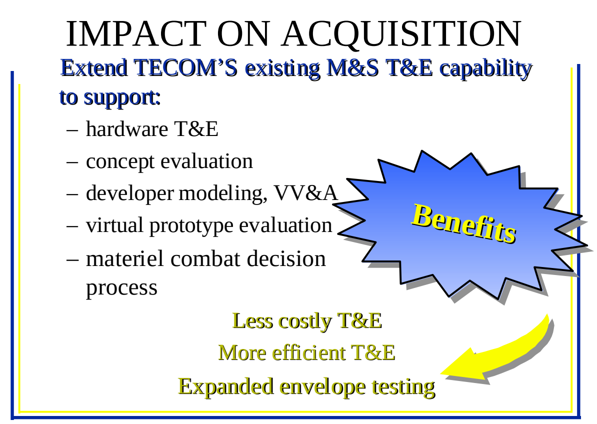
Modeling and simulation technology is also being applied to the development of virtual prototypes. Virtual prototyping is system development that is based on computer engineering models of systems, subsystems, and components. Virtual prototype designs can be verified and refined on the computer before building the hardware. We need virtual testing to test virtual prototypes. Virtual testing refers to a computer simulated test range and environment to test the virtual prototype performance that will closely parallel the actual test. We need to develop some simulated test tools for verifying these designs. These tools include the synthetic test stimuli; ground truth database; interface architecture; and test standards and procedures. [1]

Current technology advances enable us to model actual test ranges in sufficient detail and fidelity so they can be represented in interactive computer graphics. The level of fidelity determines the reality physical characteristics of of the model and its graphic images. Virtual test ranges provide the benefits of testing many system requirements without being physically placed on the ground at the actual test range.

Another advantage is that design concepts and prototypes that are not ready for physical testing can be tested in the virtual range to examine performance. Besides the ability to influence design in a less costly way and to focus and minimize testing, the virtual approach offers an extension of testing beyond normal safety envelopes and beyond normal range boundaries. Most of all, virtual testing is completely nondestructive.

A dynamic and interactive database is essential to conduct virtual testing. It is used to generate synthetic representations of terrain, ranges, and threat environments. These simulated test tools will be available on an open architecture and internet for customer access. This network allows the system developer to “dial-up” the ground truth data, virtual test range and procedures and conduct testing on the virtual prototype at their work stations. The virtual prototypes are verified on the virtual test range to ensure design maturity and requirements are met. This process allows the developer to verify the system design before building the system. The use of a verified model increases the confidence that the system is being properly designed. Virtual testing offers a “model-test-model” mode versus the old way of “test-break-fix-test” mode. Ultimately, this technique offers the best possible design and increases the chance of passing the physical test with reduced time and costs.

However, simulation does not usually provide confidence unless validated with real data. We need to anchor the simulations to a real proving ground’s expertise and database. We need to ensure that the recorded performance of a system under virtual test conditions will closely parallel the actual test. [2] Finally, we need to feed back the test data into the database continuously to increase validity.



6. <u>COST SAVINGS</u>.

Modeling and simulation are expensive too. Therefore, cost, benefits, and return-on-investment must be studied before considering the use of modeling and simulation. The program managers need to understand that modeling and simulation can increase research, development, test, and evaluation (RDT&E) dollars, but the eventual payback in production and hardware testing can be significant. Most of all, our goal is to get the best equipment to our soldiers faster and cheaper.

Modeling and simulation offset the number of rounds required for a live-fire test. It enables the assessment of the vulnerability of a combat vehicle without firing the full spectrum of rounds. Computer modeling helps to predict the damaged components inside the combat vehicle so shots can be avoided that could be catastrophic and destroy the test assets. A typical live-fire shot can cost up to $2,000 per round against a highly complex target like a tank. [3] This cost includes the ammunition and labor. It does not account for the damage done to the tank.

The following two programs have undergone development. They reflect cost reductions and improved predictive capabilities with the use of modeling and simulation.

First, the Firing Impulse Simulator (FIS) at the U.S. Army Aberdeen Test Center (ATC), Aberdeen Proving Ground, Maryland, simulates live-fire testing of 105 mm to 8-inch large caliber weapons for tanks, howitzers, and towed howitzers. [3] The FIS delivers approximately 3 million pounds of force to a system under test to fully replicate an actual firing without the use of ammunition. The FIS project was a $6.9M investment in simulation technology. [3] Simulated firing with the FIS was performed on the M1A2 trunnion test program in May 1994 for $500,000. [4] This test would cost $31.7M if live rounds were used at about $2,000 per round for a typical trunnion-bearing test. [4] About 90 percent of the rounds were simulated, and hence reduced the cost of testing. [4] Nonammunition firings result in significant cost savings and significant environmental benefits, such as eliminating noise, toxic fumes, and blast overpressures.

Second, the Simulation/Test Acceptance Facility (STAF) at the U.S. Army Redstone Technical Test Center (RTTC), Alabama, provides testing of a fully assembled “live” missile with multiple computer-based test scenarios, such as targets, ranges, and temperatures. [5] RTTC conducted a detailed cost tradeoff for the LONGBOW missile program. Some assumptions entered into this analysis were: destructive firing of four missiles a month was replaced by the STAF method of simulating/testing six missiles per month. Destructive firing of four missiles per year was used as an additional confidence builder and feedback to the model. If destructive test programs were performed on the LONGBOW, the yearly test cost would be $12.5M. [5] The STAF simulation/test method, however, costs only $1.8M per year. This results in a cost avoidance of $10.6M per year. [5]

The more significant cost savings expected of modeling and simulation will emanate from decreased development times and fewer design modifications after a system is cast in hardware. [6]

7. TIME SAVINGS.

The Moving Target Simulator test facility at ATC is designed to assess the ability of the M1A1 tank crew to track and fire on images of simulated maneuvering helicopters. Approximately 500 simulated engagements were completed in about 3 weeks. [7] It would require 2 weeks just to setup and fire a single live shot. [7] The effect on acquisition time can be less time spent in testing and retesting.

8. RISK REDUCTION.

Modeling and simulation also make it possible to gather more and better data than was previously possible. The effect on acquisition risk is earlier availability of more performance data on which to base decisions. Modeling and simulation identify early design risks and strengthens milestone decisions. Once systems reach the hardware stage, they will have undergone refinements and adjustments as a result of simulations.

9. SUMMARY.

The acceleration of technology advancements coupled with decreasing financial resources is a challenge. It is clear that modeling and simulation must play an increasing role in complementing the test and evaluation mission. The VPG is intended to provide ground truth data and synthetic test stimuli to support hardware or virtual prototype testing. The VPG will be widely networked to provide test and evaluation resources and "internet type" customer access. However, hardware testing cannot be replaced by virtual testing but allow to properly scope hardware testing augmented and extended by virtual testing. The results of simulation will identify those areas that require the most effort to resolve. Actual testing will be significantly reduced and specifically targeted at weaknesses identified by simulation. Application of modeling and simulation technology to DT&E will reduce the time, resources, and cost of determining the true performance potential of new weapons technologies.

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